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THE PRESENT STATE OF SERIES PRODUCTION OF BASIC
VACUUM-TECHNIQUE COMPONENTS IN CZECHOSLOVAKIA

by

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By: J. Buril

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ABSTRACT: The article discusses the increasing requirements and the multiplicity of the practical use of vacuum equipment and the resulting problems. A short survey of the basic parts of vacuum devices and of the rules for their operation is given. Orig. art. has: 6 figures. English Translation: 13 pages.

THE PRESENT STATE OF SERIES PRODUCTION OF BASIC VACUUM-TECHNIQUE
COMPONENTS IN CZECHOSLOVAKIA

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The paper discusses the problem of vacuum-system construction posed by the ever-increasing demand for and manifold uses of vacuum technique. It gives a brief review of the basic components of vacuum systems and their working principles.

INTRODUCTION

One of the characteristic technical phenomena of the past two decades has been, without doubt, the rapid development of vacuum technique and its introduction into an increasing number of scientific and industrial branches. This situation has not been without effect upon the refinement and mass production of the basic vacuum installations already in existence, and on the development of entirely new elements, especially of pumps for ultrahigh vacuum. However, the many aspects of vacuum-technique applications at times confront the designer with hard-to-solve problems stemming from the demand for a wide range of rather complex and varied vacuum installations. Basically, two possible approaches to the solution are possible: the manufacturing of unique installations meeting individual requirements, or the mass production of basic building blocks and standard installations (either universal or admitting of adaptation to the specific requirements).

The majority of the world's producers of vacuum apparatus have opted for the second solution, i.e., the production of a wide range of

basic building blocks from which complex vacuum installations can be built, since this solution is far more economical.

VHJ Laboratory Equipment Prague, the design office for vacuum equipment for the laboratory instrument division in Czechoslovakia, has also committed itself to this method and is progressively introducing these basic building elements of vacuum technique into its production program.

The transition to this type of production has not been easy. It was above all necessary to improve the performance levels of the existing pumps and their technical parameters, to standardize the design concepts and basic dimensions of the elements presently manufactured, to standardize the fittings, connections, etc. Today, the development of vacuum building blocks has been extensively defined and is being carried out according to a precisely established plan.

The purpose of the present paper is to inform the reader concerning the principal features of the current production situation and of the available mix of basic vacuum building blocks. The individual sections will echo the basic principles, often overlooked in practice, which have to be observed for trouble-free functioning of the individual components and the installations as a whole.

THE BASIC BUILDING BLOCKS

The basic building blocks of vacuum technique include those components of low- and high-vacuum installations designed for all uses which are common to these installations and from which the basic equipment aggregate can easily be built. These components can, therefore, be mass-produced in specific dimensions.

These are, generally speaking,

I. pumps;

vacuum gauges;

valves and valve blocks.

II. oil-vapor traps and freezers;

connecting pipes and fittings.

III. vacuum-tight electrical entrances;

entrances for transmitting motion into the vacuum.

The Roman numerals of the individual groups denote the order of priority according to which the individual components will be introduced into production. A special group is formed by elements that automate functioning of vacuum installations and the components for ultra-high vacuum.

PUMPS

From the point of view of functional and perhaps even design principles, present-day vacuum technique offers a large number of pump types. Of these, the most successful in low-vacuum installations have been the rotary-valve pumps. In installations requiring very high pumping performance, these pumps are used together with Roots-type pumps. High-vacuum installations use diffusion pumps in addition to rotary pumps.

Table 1 reviews all of the vacuum-pump types manufactured at the State Laboratory Equipment Works and the degrees of vacuum that they can produce.

Water pumps are used only to obtain gross low pressures in small spaces. Their principal uses are in laboratories, for filtration, etc. These pumps reach their optimum pumping speeds at a water flow rate of 440 liters per hour and pressures of 4 atm gauge. They are equipped with a nonreturn valve that makes it impossible for water to flow back into the evacuated space.

The dry-motor pump is also used to obtain gross low pressures in small containers. Its advantage over the water pump lies in its inde-

pendence of the water supply and also in its being able to serve as a compressor.

The two types of pumps cited, i.e., water and motor pumps, are not included among the basic building blocks for vacuum installations.

Rotary oil pumps are basic building blocks in a large majority of conventional vacuum installations. Table 2 shows the types of pumps presently manufactured as well as additions to the series planned for the near future.

The table also shows that, with the exception of the smallest pumps with their $3\text{m}^3/\text{hour}$ output, all the new series of pumps will come in two-stage types. Figures 1 and 2 show Laboratory Equipment rotary pumps in the new series.

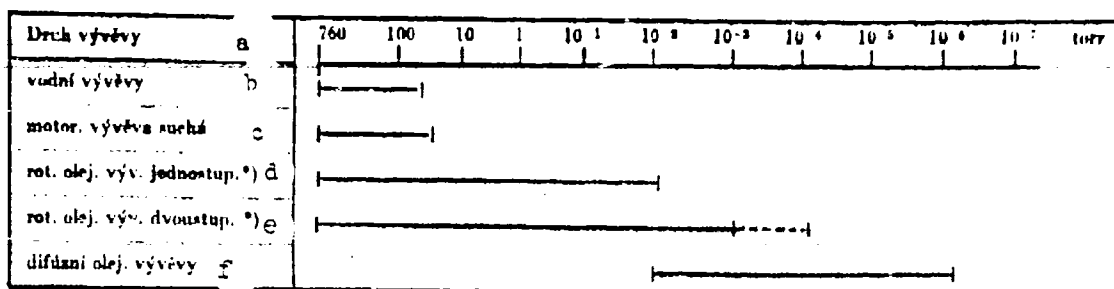
When developing new types of rotary pumps, special attention has been devoted to:

- improvement of the maximum vacuum by about 1 order, i.e., with the two-stage pumps, this represents the possibility of obtaining partial pressures of the order of 10^{-4} torr,
- quiet operation;
- air cooling instead of water cooling;
- long life of the pump and oil filler;
- production simplicity

The intake-port diameters of the rotary pumps in the new series form one of the basic elements in dimensional standardization of the coupling components. At the same time, the individual diameters of the pumping ports of all the two-stage pumps in the new series are chosen in such a manner as to assure that, when fitted with a suction pipe up to 1 m long (and having the same diameter as the intake stub of the rotary pump), the transfer capacity of this pipeline at a pressure of 10^{-1} torr will be at least ten times the nominal pumping speed of the

TABLE 1

Working Ranges and Partial Pressures Obtained with the Pumps Presently Manufactured by Laboratory Equipment



Explanation: ——— denotes the value for presently manufactured types; ----- denotes the performance of experimental types.

*Partial pressure measured by the MacLeod method.

a) Type of pump; b) water pumps; c) dry-motor pumps; d) rotary oil pump, one stage; e) rotary oil pump, two stages; f) oil diffusion pumps.

TABLE 2

Laboratory Equipment Rotary Oil Pumps

Typové ozn. a	RV 3	RV 5/2	RV 15	RV 20/2	RV 30	RV 40/2	RV 100/2	RV 120	RV 200/2
čerp. rychlost m ³ /hod při 760 torr b	3	5	15	20	30	40	100	120	200
současná vyráběná řada c	•	•	•		•	•		•	
řada chystaná do výroby d	•	•		•		•	•		•

a) Type designation; b) pumping speed in m³/hour at 760 torr; c) series presently manufactured; d) planned series.

TABLE 3

Review of Nominal Intake-port Diameters in the New Series of Rotary Pumps

Typ. ozn. vývěvy a	RV 3	RV 5/2	RV 20/2	RV 40/2	RV 100/2	RV 200/2
jmen. světlost v mm b	15	28	40	50	70	76

a) Type designation; b) nominal I.D., mm.

rotary pump used. This reduces the loss of pumping speed at the end of the pipe to a minimum.

Table 3 presents a series of nominal suction-pipe system diameters for the individual rotary oil pumps of the new series.

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REPRODUCIBLE**



Fig. 1. The only single stage pump in the new series of rotary oil pumps is the RV 3; air-cooled with an output of $3\text{m}^3/\text{hour}$ at 760 torr.

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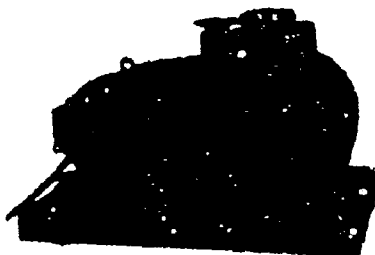


Fig. 2. The RV 40/2 pump is one of the new pump series. It is a two-stage unit, air-cooled with the aid of a high-speed fan on the motor-belt shaft.

Since there are frequent errors in the practical use of the rotary pumps, it is desirable to review certain basic rules for their application:

- rotary oil pumps are designed to pump dry air from closed spaces;
- rotary oil pumps are not suitable for pumping aggressive gases and vapors;
- the pumped gas may not contain mechanical impurities; if this is the case, a dust filter must be placed before the pump;
- in cases of pumping of moist air, it is necessary to work with an open "gas-ballast valve," connecting a condenser or perhaps even a throttle valve in front of the pump;

- the valve gear of the rotary-pump vacuum installation must be designed to permit venting of its suction pipes when the rotary pump is shut off, and also to separate the evacuated space from the pump.

Today, the oil diffusion pump is the basic high-vacuum tool. Of the many known types, the most successful has been the three-stage, water-cooled vertical oil diffusion pump with automatic fractionation of the working fluid.

The oil diffusion pumps manufactured by Laboratory Equipment are of this design (see Fig. 3). The working fluid is silicone oil with a vapor pressure of the order of 10^{-8} torr.

Table 4 gives a review of the pumping capacities of the new series of diffusion pumps. At the present time, all of the pumps offered by Laboratory Equipment are of this new type.

In the design of all diffusion pumps of this series, special attention has been paid to the following:

- high pumping speed coupled with small size;
- possibility of reaching partial pressures of the order of 10^{-7} torr;
- stability of the working fluid in case of penetration of air into the hot pump;
- long service life of the working fluid.

Let us repeat some of the basic rules and regulations for the use of diffusion pumps:

- the diffusion pump cannot work independently, but has to have a rotary oil pump in front of it;
- the diffusion pump is not able to evacuate a space at atmospheric pressure, i.e., it is necessary to evacuate it first with a suitable fore-vacuum pump to about 10^{-2} torr;
- of all the liquids, only mercury and silicone oil tolerate the

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Fig. 3. The DOV 500 oil diffusion pump represents the current series of diffusion pumps. The pump is three-stage, all-metal, water cooled, with a pumping capacity of 500 liters/second.

TABLE 4

Review of Types of Oil Diffusion
Pumps Produced by Laboratory Equip-
ment

Typ a	DOV 10	DOV 35	DOV 250	DOV 500	DOV 1000
Imenovita dorp. rychlost (ltr/s)	10	35	250	500	1000

a) Type; b) pumping capacity (liters/
/sec).

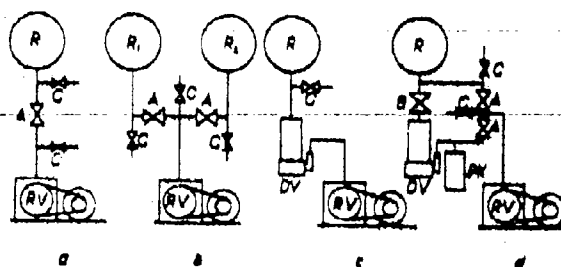


Fig. 5. Schematic design of vacuum-valve couplings; RV) Rotary pump; DV) diffusion pump; R) receiver; PK) forevacuum chamber; A, B, C) three basic types of valves.

penetration of air into the heated air pump;

- due to the possible undesirable loss of working fluid from the pump, penetration of air into the hot pump is undesirable even if sili-cone oil is used.

VACUUM GAUGES

As is apparent from Table 5, the State Laboratory Equipment Plant makes three different types of electric vacuum gauges - thermal-cell, Penning (ionization type with cold cathode) and ionization type (with hot cathode, as shown in Fig. 4), with the measuring ranges given in the table.

The gauge most frequently used in practice is a combination thermal cell and Penning vacuum gauge whose sources are in a common panel and have a common indicator. This vacuum gauge is easy to service and is used especially in industry. It is currently being improved; Penning gauge that can be taken apart and cleaned easily is being developed; extension of the measuring range and the possibility of connecting a recorder or an automatic control valve responding to the vacuum obtained are being investigated.

Let us repeat some of the basic rules and regulations governing the use of vacuum gauges;

- great care must be devoted to the placement of gauges, especially in high-vacuum installations, since otherwise the measured values may differ from the truth by as much as one order;

- the placement of the gauges must be such as to prevent fouling in use by mechanical impurities or oil;

- in high-vacuum installations with rotary diffusion pumps and the classical five-valve coupling, it is desirable to use two thermal-cell gauges, one placed in the forevacuum chamber, the other in the high-vacuum working space;

- in case of incorrect connection of a Penning or ionization vacuum gauge, the reading may be strongly influenced by adsorption or desorption phenomena in the gauge and the immediate surroundings.

TABLE 5

Measuring Ranges of the Types of
Electrical Vacuum Gauges Manufactured
by Laboratory Equipment

Druh va- kuoměru	a							torr
	1	10 ⁻¹	10 ⁻²	10 ⁻³	10 ⁻⁴	10 ⁻⁵	10 ⁻⁶	
termo- článek b								
kombino- vaný c								
ionizační								

a) Type of vacuum gauge; b) thermal-cell; c) combined; d) thermal-cell; e) Penning; f) ionization.

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Fig. 4. Hot-cathode ionization-type vacuum gauge, type VMI, with measuring range of $1 \cdot 10^{-3}$ to $1 \cdot 10^{-7}$ torr, with built-in automatic protective device that operates in case of accidental air penetration.

VALVES

Practically all vacuum installations, even the simplest, require the use of shutoff devices in vacuum-pumping couplings. Previously, vacuum cocks were used; they have since been replaced gradually but entirely by vacuum valves, which have proven much more suitable.

Figure 5 shows a schematic of four basic possible designs for valve couplings. Figure 5a represents a simple low-vacuum pumping installation permitting evacuation of the recipient and vacuum-sealing with simultaneous or delayed venting of the rotary pump and, naturally, of the recipient space. Figure 5b shows again a low vacuum installation that evacuates, alternately or simultaneously, the two recipients

R_1 and R_2 , permits venting one of them independently of evacuation of the other, and also permits leaving the two under vacuum when the rotary pump is disconnected and vented. The valve coupling of the high-vacuum installation shown in Fig. 5c is designed for devices with long pumping periods, where the time needed for heating and cooling of the diffusion pump is very short compared to the pumping interval of one working phase. The simple valve coupling shown does not allow for sudden interruption of the power supply to the rotary pump. Figure 5d shows the classical five-valve design of the high-vacuum coupling, which permits direct forevacuuming of the recipient by the rotary pump, evacuation of the recipient to high vacuum by the diffusion pump, venting of the recipient on separation of the diffusion-pump space from the vented space and sealing of the recipient and the diffusion-pump space under vacuum on disconnection and venting of the rotary pump.

The diagrams shown indicate that for low-vacuum installations, two types of valves - A and C, which differ in diameter - are needed; the diameter of valve A is determined by the diameter of the aspiration fitting on the rotary pump used, while the diameter of the venting valves is small, being given by the time needed to vent the space involved; this is usually quite short, even when diameters of a few millimeters are used.

High-vacuum diffusion-pump installations also include in the valve coupling a valve B whose minimum diameter is again given by the diameter of the aspiration fitting of the diffusion pump used.

The need for different diameters of the valves A, B and C is what dictates that at least three basic groups of valves be used as basic elements for vacuum installations: diffusion-pump valves, valves for distribution of low vacuum, and venting valves. In addition, special valves are included. The designs of the individual types are naturally

different. At present, VHI Laboratory Equipment manufactures the following independent building blocks: a series of valves for diffusion pumps corresponding to the series of diffusion pumps manufactured and two types of valve blocks, VB 35 and VB 250 (Fig. 6), which combine two valves of type A and two valves of type C in one unit.

At present a series of independent type A valves corresponding in diameter to the new rotary-pump series is being developed. The valves will be manufactured in two variations - with manual and electromagnetic control.

As for the special valves, production of needle valves with the possibility of fine control of the gas intake into the evacuated space will begin next year.

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Fig. 6. The VB 250 valve block combines in a single unit two valves of type A and two venting valves of type C. Its size is suitable for high-vacuum installations with the RV 15 rotary pump and the DOV 250 diffusion pump.

OTHER BASIC BUILDING BLOCKS

Other basic building blocks needed for vacuum installations, such as oil-vapor traps, quick-release couplers, vacuum entrances for electrical lead-ins and shafts, etc., are, for the present, built only as components of the complete production installations. After standardization is completed, these will be introduced progressively into pro-

duction as independent building blocks conforming to the specifications of the users.

CONCLUSIONS

Because of the range of its subject the present paper has given only a basic review of the manufacture and uses of basic building blocks for vacuum installations. A more detailed discussion of the problems of determination and selection of correct pump and line sizes, the production of high-quality couplings, outfitting of vacuum installations, and a closer description of the functions and technical parameters of the new components will be given in future reports.